# Feed Utilization

## Effect of Supplementing Low Levels of Monensin to Lactating Dairy Cows Fed Alfalfa Silage

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### Introduction

When alfalfa is ensiled, typically 50-60% of the CP is converted to NPN; most of this NPN is in the form of free AA and small peptides. Microbial deamination of free AA and peptides usually exceeds incorporation into microbial protein in the rumen and most of the amino N in silage is converted to $NH_3$. Ammonia overflow from the rumen contributes to the excessive loss of urinary N by dairy cows fed alfalfa silage. Yang and Russell (1993) found that feeding Monensin reduced in vitro and in vivo ruminal $NH_3$ formation from protein hydrolysates by suppressing certain bacteria with high deamination activity. Thus, feeding Monensin may improve N efficiency by increasing gut absorption of amino acids (AA). Phipps et al. (1995) reported that feeding Monensin at 150 and 300 mg/d, but not 450 mg/d, improved milk yield in cows averaging 26.7 kg milk/d. The objective of this trial was to determine if supplementing Monensin to dairy cows fed all their forage as alfalfa silage would improve the yield of milk and milk components, improve N efficiency and reduce the need to supplement proteins resistant to ruminal degradation.

### Materials and Methods

Second-cutting alfalfa was field wilted to 40% DM and ensiled in two bunker silos. In trial 1, two sets of 24 multiparous Holstein cows were blocked by DIM and parity each into six groups and randomly assigned to one of four diets. The first set of 24 was fed the diets during part 1 of the trial (9/14/95 to 12/7/95) and the second during part 2 (from 11/2/95 to 1/25/96). The four diets were: 1) Control; 2) Control plus fish meal; 3) Monensin; and 4) Monensin plus fish meal (Table 1). Cows were fed the same diet for all 12-wk of the trial. Rumensin pre-mix was blended with ground shelled corn and included at 1% of the diet; ground shelled corn was used in the Control. The 20 weekly samples of ground corn (Control) and ground corn plus Rumensin (Monensin) were analyzed for Monensin. Monensin averaged 1062 mg/kg DM in the supplement and 10.2 mg/kg DM in the two Monensin diets (Table 1). Control diets were intended to have no Monensin; however, the ground shelled corn fed in part 2 of the trial was contaminated, containing 238 mg Monensin/kg DM. Thus, Monensin content of the Control diets averaged not 0, but 1.1 mg/kg DM during the trial (Table 1). In trial 2, eight ruminally cannulated lactating cows were blocked into two groups by DIM, randomly assigned to one of two balanced 4 X 4 Latin squares with 4-wk periods (9/28/95 to 1/18/96) and fed the same diets as trial 1 (Table 1). On d-27 of each period, strained ruminal fluid was taken from each cow at 0, 1, 2, 3, 4, and 6 h after feeding and analyzed for $NH_3$, total AA and VFA. On d-28 of each period, strained ruminal fluid was taken only at 4 h after feeding, mixed with buffer, then dispensed to tubes containing buffer only (blanks), or buffer plus casein, acid-hydrolyzed casein (CHA), or enzymatically-hydrolyzed casein (CHE). Tubes were incubated at 39°C for 0 to 3 h. Rates of release of $NH_3$ and total AA from casein, and $NH_3$ from CHA and CHE, were determined using linear regression.

### Results and Discussion

Alfalfa silage fed in these trials contained 21.0% CP (DM basis); $NH_3$, free AA plus peptides, and NPN accounted for 5, 49, and 54% of total N. Free AA plus peptide N from alfalfa silage NPN comprised 33 and 36% of total N intake in diets with and without fish meal. Thus, these diets were appropriate for testing whether Monensin reduced ruminal AA and peptide catabolism. Dry matter intake and BW gain were increased by fish meal, but there was a trend (*P* = 0.11) for Monensin to reduce DMI (Table 2) and a significant Monensin by fish meal interaction due to the low BW gain on the Monensin only diet (with lowest DMI). Milk yield was not influenced by diet but there was a significant ($P = 0.07$) reduction in fat yield with Monensin. Fish meal increased protein yield 90 g/d on Control but only 30 g/d on Monensin (Table 2). The smaller milk protein response to fish meal feeding may have been due to improved protein status of the cows fed Monensin; however, mean protein yield was 1.12 on Control and 1.10 kg/d on Monensin. During part 2 of the trial, ground shelled corn fed in the Control diets was contaminated by Monensin. Thus, the net difference in Monensin intake between cows fed Monensin and Control diets during part 1 (247 mg/d) was greater than during part 2 (193 mg/d). There was no difference ($P = 0.37$) in milk yield between Control and Monensin diets without fish meal during part 1; however, there was a trend ($P = 0.15$) for milk yield on Control without fish meal to be lower than on Monensin without fish meal during part 2. This suggested that contamination of Control diets during part 2 did not mute detection of a Monensin response. BUN was increased by fish meal but unaffected by Monensin; there was a large increase in MUN with fish meal (from 11.6 to 15.0 mg N/dL; $P < 0.01$) and a small increase in MUN with Monensin (from 12.9 to 13.7 mg N/dL; $P = 0.08$). Blood glucose was increased 2.6 mg/dL by Monensin and reduced 2.8 mg/dL by fish meal.

Although there were no effects of diet on ruminal $NH_3$, pH and total VFA, feeding fish meal reduced total AA (Table 3). Monensin feeding decreased acetate, butyrate and acetate: propionate ratio, and increased propionate, all commonly observed with Monensin feeding. However, these changes were small in magnitude. Fish meal slightly reduced butyrate and appeared to reduce propionate on the Control diet and to increase propionate on the Monensin diet. A Monensin by fish meal interaction also was detected for acetate: propionate ratio. In vitro degradation of casein to $NH_3$ and total AA, and $NH_3$ release from CHE (a mixture of free AA and small peptides) were not influenced by feeding either Monensin or fish meal (Table 3). However, in vitro $NH_3$ release from CHA (a mixture of free AA) was increased 6% by Monensin and 20% by fish meal. Increased ruminal deamination of free AA with fish meal was surprising and may account for the depressed total AA observed in vivo (Table 3). Overall, there was no evidence that Monensin fed to dairy cows at 250 mg/d depressed ruminal AA and peptide catabolism. Although significant, the small alterations in ruminal acetate, propionate and butyrate suggested that the amount of Monensin fed was insufficient to alter ruminal catabolism of free AA and peptides. Yang and Russell (1993) fed 52 mg Monensin/kg DM when they observed a 30% reduction in ruminal $NH_3$ in vivo.

**Summary and Conclusion**

Except for a reduced fat yield, supplementing an alfalfa silage based diet with 250 mg Monensin/d did not alter yield of milk and milk components. Fish meal feeding increased protein yield on both Control and Monensin diets, indicating that the basal ration was limiting in absorbable protein. There was a nonsignificant trend for lower protein response to fish meal on Monensin. Monensin increased blood glucose and ruminal propionate, and decreased ruminal acetate, butyrate and acetate: propionate ratio. That these changes were smaller than is usually observed suggested that Monensin was fed at too low a level. There was no evidence that feeding Monensin at 250 mg/d (10 mg/kg DM) reduced ruminal AA and peptide catabolism. Additional trials with alfalfa silage based rations are needed to confirm that feeding Monensin improves ruminal N metabolism and milk yield in lactating dairy cows and to identify a possible optimal level of dietary Monensin.

## References

Phipps, R. H., B. A. Jones, J.I.D. Wilkinson, and M. D. Tarrant (1995). Effect of monensin on milk production of Friesian dairy cows in the United Kingdom. J. Dairy Sci. 78 (Suppl. 1): 268 (Abstr.).

Yang, C.M.J., and J. B. Russell (1993). Effect of monensin on the specific activity of ammonia production by ruminal bacteria and disappearance of amino nitrogen from the rumen. Appl. Environ. Microbiol. 59: 3250-3254.

Table 1. Composition of diets (Trials 1 and 2).

| Item | Control | Control + Fish Meal | Monensin | Monensin + Fish Meal |
|---|---|---|---|---|
| | | (% of DM) | | |
| Alfalfa silage | 56.4 | 56.4 | 56.4 | 56.4 |
| High moisture ear corn[1] | 38.8 | 35.8 | 38.8 | 35.8 |
| Solvent soybean meal | 2.8 | 2.8 | 2.8 | 2.8 |
| Fish meal[2] | - - - | 2.9 | - - - | 2.9 |
| Dicalcium phosphate | 0.6 | 0.6 | 0.6 | 0.6 |
| Trace mineral salt (+ Se) | 0.3 | 0.3 | 0.3 | 0.3 |
| Dynamate | 0.06 | 0.06 | 0.06 | 0.06 |
| Vitamins A, D, E Premix | 0.1 | 0.1 | 0.1 | 0.1 |
| Ground shelled corn[3] | 0.96 | 0.96 | - - - | - - - |
| Monensin supplement[4] | - - - | - - - | 0.96 | 0.96 |
| Mean composition (DM basis) | | | | |
| CP (%) | 16.8 | 18.6 | 16.8 | 18.6 |
| $NE_L$ (Mcal/kg) | 1.67 | 1.66 | 1.67 | 1.66 |
| NDF (%) | 29 | 29 | 29 | 29 |
| Monensin (mg/kg)[3] | 1.1 | 1.1 | 10.2 | 10.2 |

[1]High moisture ear corn was ground through a 3/8” screen.
[2]Low solubles fish meal (“Sea-Lac,” Zapata Proteins, Hammond, LA).
[3]Control, ground shelled corn fed during the second half of the trial (weeks 11 to 20) was contaminated with Monensin at the UW Feed Mill at Arlington. Control diets contained 0 Monensin during weeks 1 to 10 and 2.28 mg Monensin/kg DM during weeks 11 to 20 (mean 1.14 mg/kg DM).
[4]Monensin supplement was mixed with ground shelled corn and commercial Rumensin pre-mix, blended at the UW Feed Mill at Arlington to contain 1,200 mg Monensin/kg DM and found to contain a mean of 1062 mg Monensin/kg DM.

Table 2. Effect of Monensin and fish meal supplementation on DMI, BW gain, milk composition and yield, milk urea and blood urea and glucose (Trial 1)[1].

| Item | Control | Control + 3% FM | Monensin | Monensin + 3% FM | SE | $P > F$[2] Diet | Contrasts Mon | Contrasts FM | Contrasts Mon x FM |
|---|---|---|---|---|---|---|---|---|---|
| Mon intake, mg/d | 28 | 29 | 243 | 257 | . . . | . . . | . . . | . . . | . . . |
| DMI, kg/d | 24.7 | 25.4 | 23.8 | 25.2 | 0.6 | 0.100 | 0.109 | 0.068 | 0.532 |
| BW gain, kg/d | 0.57 | 0.52 | 0.33 | 0.68 | 0.07 | 0.010 | 0.569 | 0.038 | 0.007 |
| Milk, kg/d | 35.4 | 38.2 | 36.0 | 37.3 | 1.1 | 0.287 | 0.308 | 0.118 | 0.612 |
| 3.5% FCM, kg/d | 33.2 | 34.4 | 32.2 | 33.0 | 1.1 | 0.341 | 0.102 | 0.428 | 0.932 |
| Milk composition, % | | | | | | | | | |
| Fat | 3.26 | 2.92 | 2.95 | 2.88 | 0.12 | 0.089 | 0.110 | 0.133 | 0.174 |
| Protein | 3.07 | 3.05 | 3.07 | 3.03 | 0.05 | 0.959 | 0.624 | 0.862 | 0.875 |
| Lactose | 4.74 | 4.70 | 4.83 | 4.78 | 0.05 | 0.699 | 0.309 | 0.948 | 0.558 |
| SNF | 8.53 | 8.44 | 8.60 | 8.52 | 0.08 | 0.957 | 0.858 | 0.955 | 0.602 |
| Yield, kg/d | | | | | | | | | |
| Fat | 1.12 | 1.10 | 1.04 | 1.05 | 0.04 | 0.306 | 0.071 | 0.918 | 0.573 |
| Protein | 1.07 | 1.16 | 1.08 | 1.11 | 0.03 | 0.113 | 0.163 | 0.060 | 0.447 |
| Lactose | 1.65 | 1.79 | 1.72 | 1.77 | 0.06 | 0.362 | 0.533 | 0.134 | 0.459 |
| SNF | 2.97 | 3.22 | 3.05 | 3.14 | 0.10 | 0.260 | 0.343 | 0.107 | 0.473 |
| Efficiency, | | | | | | | | | |
| Milk/DMI | 1.45 | 1.51 | 1.53 | 1.49 | 0.02 | 0.692 | 0.583 | 0.808 | 0.300 |
| MUN, mg N/dL | 11.35 | 14.41 | 11.90 | 15.51 | 1.85 | < 0.001 | 0.079 | < 0.001 | 0.530 |
| BUN, mg N/dL | 13.06 | 16.66 | 12.99 | 16.85 | 0.81 | < 0.001 | 0.918 | < 0.001 | 0.804 |
| Blood Glc, mg/dL | 52.8 | 49.9 | 55.3 | 52.6 | 5.7 | 0.079 | 0.077 | 0.053 | 0.947 |

[1]BUN = Blood urea N, FM = fish meal, Glc = glucose, Mon = Monensin, MUN = milk urea N.
[2]Probabilities of significance for diet and orthogonal contrasts.

Table 3. Effect of Monensin and fish meal supplementation on DMI, ruminal ammonia, total AA, pH, VFA and rates of in vitro N catabolism (Trial 2)[1].

| | | | | | | $P > F$ [2] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Contrasts | | |
| Item | Control | Control + 3% FM | Monensin | Monensin + 3% FM | SE | Diet | Mon | FM | Mon x FM |
| Monensin intake, mg/d | 27 | 26 | 227 | 227 | . . . | . . . | . . . | . . . | . . . |
| DMI, kg/d | 22.3 | 21.4 | 22.5 | 22.5 | 1.0 | 0.820 | 0.381 | 0.813 | 0.784 |
| <u>Ruminal concentrations</u> | | | | | | | | | |
| $NH_3$, mM | 15.03 | 15.02 | 15.14 | 14.56 | 0.63 | 0.914 | 0.782 | 0.644 | 0.658 |
| Total AA, mM | 3.59 | 2.36 | 3.41 | 2.48 | 0.39 | 0.096 | 0.951 | 0.016 | 0.699 |
| pH | 6.15 | 6.20 | 6.24 | 6.20 | 0.04 | 0.593 | 0.322 | 0.911 | 0.362 |
| Total VFA, mM | 135.0 | 131.4 | 130.7 | 135.4 | 2.6 | 0.470 | 0.952 | 0.831 | 0.130 |
| <u>Individual VFA, mol/100 mol</u> | | | | | | | | | |
| Acetate | 63.2 | 64.4 | 63.5 | 62.6 | 0.3 | 0.008 | 0.023 | 0.646 | 0.004 |
| Propionate | 20.4 | 18.1 | 20.1 | 20.4 | 0.4 | 0.003 | 0.024 | 0.027 | 0.006 |
| Acetate: propionate ratio | 3.16 | 3.65 | 3.21 | 3.12 | 0.09 | 0.006 | 0.026 | 0.051 | 0.010 |
| Butyrate | 11.2 | 12.0 | 10.9 | 11.6 | 0.1 | < 0.001 | 0.012 | < 0.001 | 0.842 |
| Isobutyrate | 1.25 | 1.33 | 1.35 | 1.30 | 0.02 | 0.019 | 0.098 | 0.421 | 0.007 |
| Isovalerate + 2-Methyl butyrate | 1.98 | 2.21 | 2.16 | 2.10 | 0.07 | 0.187 | 0.607 | 0.261 | 0.070 |
| Valerate | 1.95 | 2.01 | 2.01 | 2.05 | 0.02 | 0.098 | 0.061 | 0.088 | 0.687 |
| <u>In vitro N catabolism rates, nmol/(hr*mg protein)</u> | | | | | | | | | |
| $NH_3$ release from casein | 86.0 | 85.1 | 80.0 | 79.9 | 7.1 | 0.917 | 0.606 | 0.917 | 0.627 |
| TAA release from casein | 17.8 | 18.1 | 8.2 | 11.0 | 3.7 | 0.330 | 0.137 | 0.641 | 0.401 |
| $NH_3$ release from CHA | 299.1 | 356.9 | 312.9 | 380.3 | 15.7 | 0.053 | 0.059 | 0.039 | 0.689 |
| $NH_3$ release from CHE | 324.5 | 397.2 | 350.7 | 388.7 | 20.1 | 0.315 | 0.211 | 0.194 | 0.717 |

[1]CHA = Acid-hydrolyzed casein, CHE = enzymatically-hydrolyzed casein, FM = fish meal, Mon = Monensin, TAA = total AA.
[2]Probabilities of significance for diet and orthogonal contrasts.